CMOS IMAGE SENSORS HAVING A TRANSFER GATE ELECTRODE, AND METHODS OF FABRICATING CMOS IMAGE SENSORS HAVING A TRANSFER GATE ELECTRODE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35 U.S.C. §119 to Korean Patent Application No. 10-2014-0022129, filed on Feb. 25, 2014, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Field

The present disclosure relates to complementary metal-oxide-semiconductor (CMOS) image sensors and methods of fabricating the same.

2. Description of Related Art

In recent years, with the development of information and communications technology (ICT) and digitization of electronic devices, image sensors having improved performance have been used in various fields of, for example, digital cameras, camcorders, portable phones, personal communication systems (PCSs), game machines, security cameras, and medical micro cameras. In general, the image sensor may include a pixel array including photodiodes (PDs) and a peripheral circuit region. A unit pixel may include a photodiode PD and a transfer transistor. The transfer transistor may be disposed between the photodiode PD and a floating diffusion region and may transfer charges generated by the photodiode PD to the floating diffusion region.

SUMMARY

Some embodiments of present inventive concepts provide a complementary metal-oxide-semiconductor (CMOS) image sensor, which may prevent an electric field crowding effect and reduce a gate-induced drain leakage (GIDL) current.

Some embodiments of present inventive concepts provide a method of fabricating the CMOS image sensor, which may prevent an electric field crowding effect and reduce a GIDL current.

In accordance with an aspect of present inventive concepts, a CMOS image sensor includes a substrate including a pixel array and a peripheral circuit region, a photodiode and a floating diffusion region formed in the pixel array of the substrate, a transfer gate insulating layer and a transfer gate electrode formed on the substrate between the photodiode and the floating diffusion region, and a peripheral gate insulating layer and a peripheral gate electrode formed on the peripheral circuit region. The transfer gate electrode includes a first edge that is rounded to have a first radius of curvature. The peripheral gate electrode includes a second edge that is rounded to have a second radius of curvature smaller than the first radius of curvature.

In accordance with another aspect of present inventive concepts, a CMOS image sensor includes a photodiode formed on a substrate, a floating diffusion region spaced a predetermined distance apart from the photodiode and formed on the substrate, and a transfer gate insulating layer and a transfer gate electrode formed on the substrate between the photodiode and the floating diffusion region. A top surface of the substrate on which the photodiode is formed is at a higher level than a top surface of the substrate on which the floating diffusion region is formed.

In accordance with another aspect of present inventive concepts, a method of fabricating a CMOS image sensor includes forming a device isolation layer on a substrate to define a pixel active region, forming a photodiode on the pixel active region, forming a floating diffusion region in the substrate to be spaced apart from the photodiode, forming a transfer gate insulating layer and a transfer gate electrode overlapping the photodiode and the floating diffusion region, forming an mask pattern to expose a first edge of the transfer gate electrode on the floating diffusion region and the floating diffusion region, rounding the first edge and recessing the exposed floating diffusion region, removing the etch mask pattern, and oxidizing surfaces of the transfer gate electrode and the substrate.

Specific particulars of other embodiments are included in detailed descriptions and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features and advantages of present inventive concepts will be apparent from the more particular description of various embodiments of present inventive concepts, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of present inventive concepts. In the drawings:

FIG. **1** is an equivalent circuit diagram of a unit pixel included in a complementary metal-oxide-semiconductor (CMOS) image sensor according to some embodiments of present inventive concepts;

FIG. **2** is a layout of a CMOS image sensor according to some embodiments of present inventive concepts;

FIG. **3** is a cross-sectional view taken along lines I-I' and II-II' of FIG. **2**;

FIGS. **4**A through **4**H are cross-sectional views taken along lines I-I' and II-II' of FIG. **2**, illustrating a method of fabricating a CMOS image sensor according to some embodiments of present inventive concepts;

FIG. **5** is a block diagram of an electronic device including an image sensor according to some embodiments of present inventive concepts; and

FIGS. **6** through **10** are diagrams of examples of a multimedia device to which an image sensor according to some embodiments of present inventive concepts is applied.

DETAILED DESCRIPTION

Present inventive concepts will now be described more fully hereinafter with reference to the accompanying drawings, in which various embodiments of present inventive concepts are shown. Present inventive concepts may, however, be embodied in different forms and should not be construed as limited to embodiments set forth herein. Rather, these embodiments are provided so that this disclosure is thorough and complete and fully conveys the scope of present inventive concepts to one skilled in the art.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of present inventive concepts. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising,", "includes" and/or "including",